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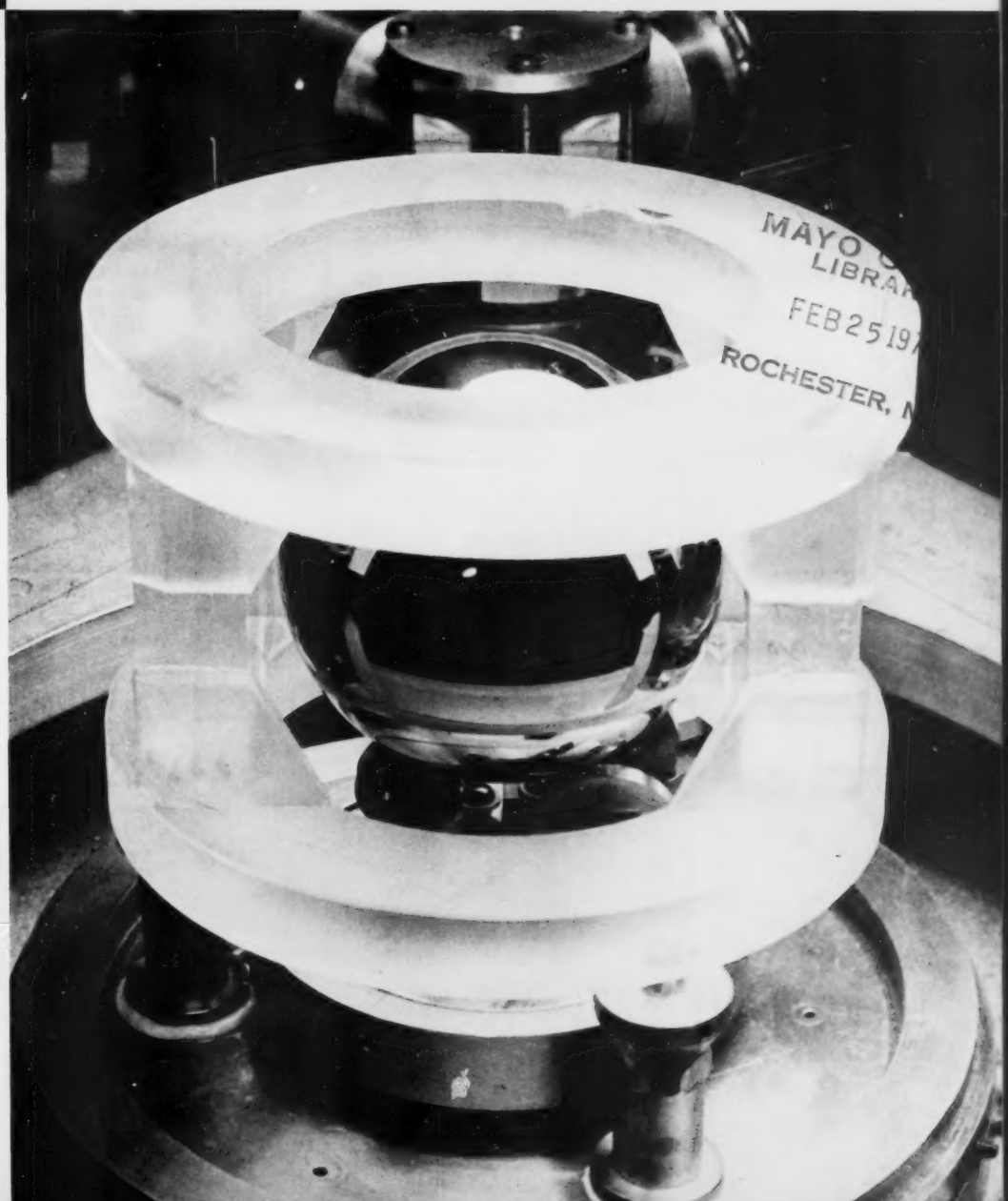
NATIONAL BUREAU OF STANDARDS

Technical News Bulletin



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UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS
Technical News Bulletin
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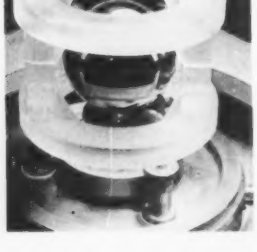

COVER: *A special interferometer has been developed for determining the diameter of spherical objects. See page 4 for further details.*

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

Center for Radiation Research

Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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PROGRAM TO IMPROVE TRANSFER OF KILOWATT-HOUR

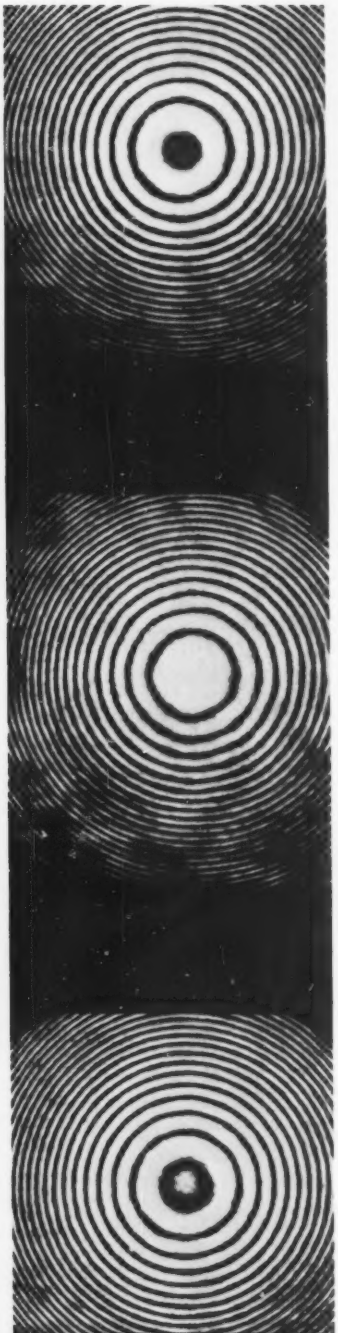
THE BUREAU AND THE EDISON ELECTRIC INSTITUTE ARE COOPERATING in research to investigate the accuracy of transferring the kilowatt-hour from NBS to power companies. S. R. Houghton, an engineer from the New England Power Service Co., has been appointed as a Research Associate by the Institute to conduct the 2-year program, which began October 1. He will work at NBS, under the general direction of NBS engineers, and in the meter laboratories of selected power companies.

The kilowatt-hour is the basic unit on which a customer is charged and, thus, on which the revenue of a power company depends. Mr. Houghton will first determine how effectively this unit is transferred from where it is established at NBS to these companies. He will then investigate ways to improve its transfer and maintenance, and its use in the calibration of the many watt-hour meters the company installs on customer premises.

The research is needed, in part, because of the rapidly growing practice of accepting or rejecting large batches of watt-hour meters by testing only a small sample. This requires a very accurate standard meter and an even more accurate reference meter. An extension of time between calibrations of meters

Continued on page 17

S. R. Houghton, Research Associate at NBS from the New England Power Service Company, adjusts the power to the NBS wattmeter calibration console. Mr. Houghton is investigating means for improving the transfer of the kilowatt-hour from NBS to power companies, maintaining this accuracy at the power companies, and improving the calibration of consumer watt-hour meters.



Typical fringes produced by the interferometer during a measurement.

INTERFEROMETER DEVELOPED TO MEASURE SPHERE AND CYLINDER DIAMETERS

AN INTERFEROMETER HAS BEEN DEVELOPED FOR MEASURING DIAMETERS OF SPHERES AND CYLINDERS.[1] The device, designed and constructed by J. B. Saunders of the Optical Physics Division, was intended primarily for accurate volumetric measurements of spherical specimens for density determinations. It should prove valuable, however, for other applications such as measuring ball bearings and components for precision instrumentation. The interferometer is believed to be the most accurate device in existence for obtaining such measurements.

A prototype instrument has been built and used at the Bureau that can measure specimen diameters in the range from 6.2 mm to 6.2 cm with an uncertainty of less than a micrometre; its precision is an order of magnitude better. Interferometers based on the same principle could be constructed to measure specimens of almost any diameter.

Basically, the device operates by comparing the specimen with an etalon of known dimensions. Interference is produced by light reflected from the surfaces of the etalon and the adjacent surfaces of the specimen. Measurements are made on several different diameters and averaged for the final value.

For a measurement, light from a stablized helium-neon laser is focused to a small area by a microscope objective and passed through a collimator. The collimated beam is then divided by a beam-splitting prism, and the resulting two beams are reflected by mirrors toward opposite sides of the specimen to be measured. The beams pass through the etalon plates to their inner surfaces, where part of each beam is reflected back to the mirror and beam splitter. A portion of each beam is also transmitted through the inner surface of the etalon, where it strikes the specimen and is reflected back through the etalon plate to the mirror and beam splitter. Interference is formed by the light reflected from the etalon inner surface (plane wavefront) and light reflected from the specimen (spherical wavefront).

To measure the diameter of a ball or cylinder, a photograph is taken of the fringe pattern returning from first one side and then the other of the specimen. This is achieved by intercepting one of the beams by a movable screen pivoted about the beam splitter. The sum of the orders of interference at the centers of the two interferograms is a measure of the gaps between the specimen and the etalon plates. Thus, since the etalon space is known, the diameter of the sphere or cylinder can be computed.

As the specimen is compared to the etalon, the separation of the etalon plates must be known accurately. This measurement is

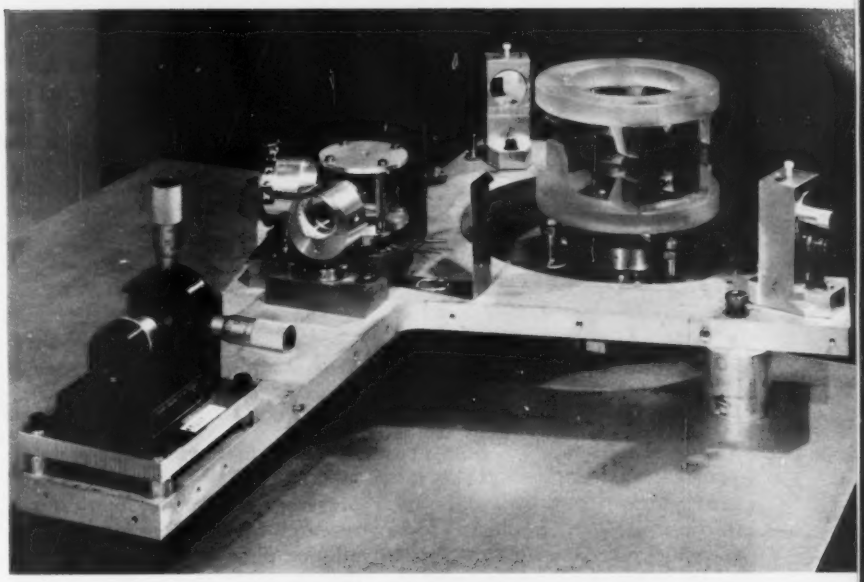
achieved by using the etalon surfaces as a Fabry-Perot interferometer. The order of interference produced by this interferometer gives a measure of the surface separation. The cavity can be remeasured subsequently by the same method without removing the etalon from its temperature-controlled housing.

The contrast of the fringes depends upon the relative intensity of the two beams. The magnification (or size) of the fringes is proportional to the distance from the focal point to the plane in which they are observed. Optimum contrast and magnification are obtained by a suitable choice of reflection, transmission, spacings, and powers of the optical components.

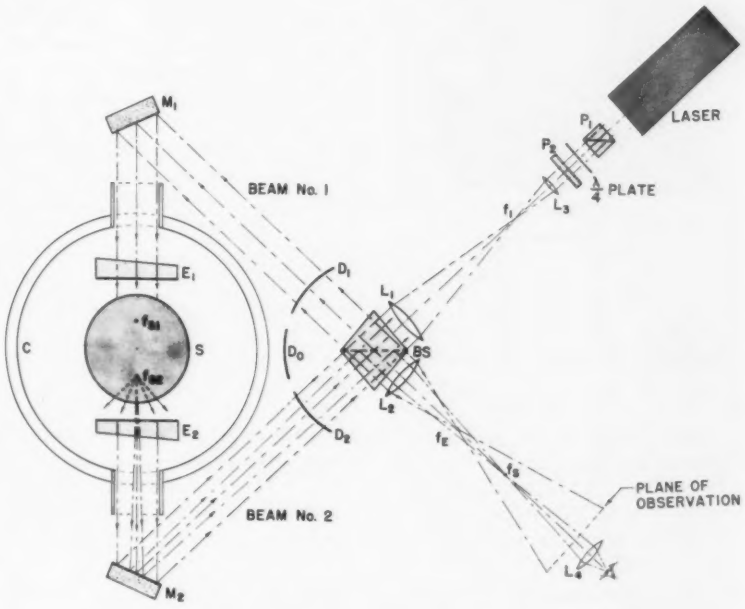
The device is actually a combination of several interferometers: A triangular interferometer formed by the beam splitter and the two mirrors; a Fabry-Perot interferometer formed by the two etalon surfaces; and two Fizeau interferometers formed by the adjacent surfaces of the specimen and the etalon plates.

The etalon plates are equally wedge shaped. They are mounted so that the inner and outer surfaces are parallel, respectively. This arrangement permits the elimination of light reflected from the outer surfaces of the plates. When the beams between the etalon and mirrors are parallel to each other, the two beams inside the etalon, before their incidence on the specimen, are also parallel. This insures that the rays (one of each beam) are incident normal to the ball and are incident at opposite ends of a common diameter. This is an essential requirement for precise measurements and insures that $d_1 + d_2 + 2r = d$, where r is the radius of the ball, d is the etalon cavity, and d_1 and d_2 are the gaps between the etalon plates and the specimen. By measuring $d_1 + d_2$, r is readily calculated since d is known.

[1] Saunders, J. B., Ball and cylinder interferometer, J. Res. Nat. Bur. Stand. (U.S.) (in preparation).



Interferometer developed at NBS to measure diameters of spheres and cylinders. Components shown in this photograph are: microscope objective (left), collimator and beam splitter (left center), specimen in etalon (right center), and mirrors on either side of etalon.

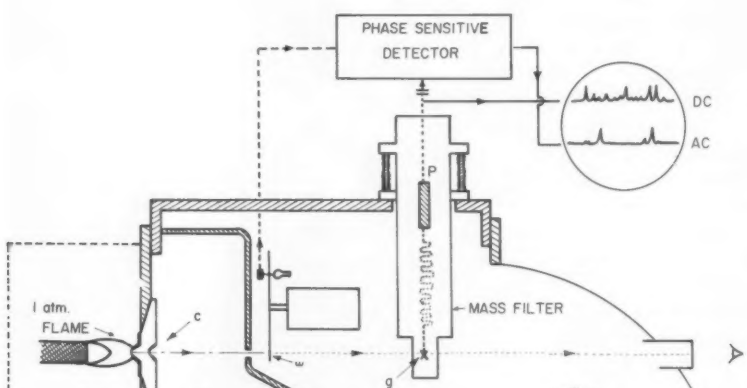


Schematic diagram of the interferometer for measuring sphere and cylinder diameters. Main components are: beam-splitting prism (BS), mirrors (M_1 & M_2), etalon plates (E_1 & E_2), specimen (S), polarizing prism (P_1), parallel plate for lateral adjustments (P_2), and screens for intercepting either beam (D_1 & D_2).

HIGH PRESSURE MASS SPECTROMETRIC SYSTEM

APPLICATION IN FLAME AND FLAME-RETARDANT ANALYSIS

A "HIGH PRESSURE" MASS SPECTROMETRIC SAMPLING SYSTEM HAS BEEN CONSTRUCTED by J. W. Hastie and A. B. Sessoms of the Institute for Materials Research for the direct analysis of flames and gaseous pyrolysis products.[1,2] Designed to overcome several problems found in studying condensable or highly reactive intermediates at low or atmospheric pressures, the new system extends research on burning- and flame-inhibition phenomena over an exceptionally wide range of pressures, temperatures, and molecular weights. With this apparatus it is possible to sample and measure chemical species of high reactivity, such as radicals, from small, well-defined regions of a flame.



Schematic of the high pressure mass spectrometer system. The sampling of flames or pyrolyzing systems is carried out in region I. A representative gas sample passes through a cone system (c) into an evacuated chamber (region II). The beam then passes through an adjustable orifice into region III, which contains a chopping wheel (w) for modulating the beam, an ion gun (g) for partial conversion of the molecular species into positive ions, a mass filter and a particle detection system (P).

In cooperation with the Bureau's Office of Flammable Fabrics, the system is being utilized in a general research program on the mechanisms of flame retardancy and the flame-retardant properties of inorganic and metal-organic compounds. Much detailed information on the effects of flame-retardant additives can be obtained from measurements of the various chemical species present in the different regions of the flame. The combination of antimony oxide, Sb_2O_3, with organic materials containing halogens (chlorine and bromine) is an effective commercial flame retardant for many fabric and polymer systems. While the halogen compounds may themselves act as flame retardants, the presence of antimony compounds appears to greatly enhance their effectiveness. Therefore, smaller amounts of retardant may be used to produce a given degree of flame retardancy. With the use of the high pressure mass spectrometric system, a better understanding of the chemical mechanism of this synergistic retardant action is being achieved.

Significant features of this apparatus include the use of molecular-beam modulation, high pumping efficiency, and a modified flame-

sampling cone system. Sensitivity for low-abundance species in the presence of background interference is enhanced through the use of molecular-beam modulation. High pumping efficiency results in reduction of molecular-beam path length and increases in sensitivity by minimizing beam attenuation between the sampling probe and the mass spectrometer analyzer. The system also allows experiments to be conducted on flames under ambient pressure conditions. Utilization of materials of low thermal conductivity, together with uniquely large sampling orifices in the flame-sampling cone system, minimizes experimental problems due to orifice plugging and greatly improves the utility of the system for studies involving inorganic retardant additives. The vacuum system is valved so that a cone may be replaced and the experiment continued within 1 minute.

The sampling of flames or pyrolyzing systems is carried out in either the laboratory atmosphere or a sealed chamber with a controlled flame or sample environment. A representative gas sample passes through a cone system into an evacuated chamber. To maintain the integrity of the sample as a molecular beam, the chamber pressure is held at $10^{-3}-10^{-4}$ torr (1 torr $= 1.33 \times 10^{2}$N/m^{2}) utilizing a pumping system with a speed in excess of 1000 liters per second. The beam then passes through an adjustable orifice into a second chamber which is maintained at pressure of $10^{-7}-10^{-8}$ torr by a 400-liters-per-second pumping system. This region contains a chopping wheel for modulating the beam, an ion gun for partial conversion of the molecular species into positive ions, a mass filter and a particle-detection system.

Condensation of inorganic material around the cone orifice and consequent plugging has been a major problem in previous flame studies. A fourfold approach was used to reduce this problem. Design changes have been made in the geometry of the first sampling chamber and the flange that holds the primary and secondary cones to provide minimal reduction in pumping. The optimum design in pumping capability then allows a considerably larger sampling orifice to be used, about a 0.004-inch diameter as compared to previous use of 0.001–0.002-inch orifices. Thus the time required to plug the orifice is greater by approximately a factor of 10. To allow the cone tip to remain hot during sampling, thereby reducing the probability of condensation, materials with relatively low thermal conductivity such as stainless steel, quartz, and lava have been used for the primary cone. The use of variable frequency-beam modulation and lock-in detection increases the detectability limits, at least by several orders of magnitude. Hence a lower concentration of additives can be used, which further decreases the cone-plugging problem. Also, the retrieval speed of mass spectrometric data has been electronically optimized.

As requirements for reducing the flammability of fabrics become more stringent, it has become increasingly important to develop a detailed understanding of the mechanisms by which flame retardants operate at the molecular level. Knowledge of these essential chemical processes can permit more sophisticated design of retardants for particular applications and perhaps define the performance limits to be expected of particular retardant systems under service conditions.

Numerous explanations have been offered for the synergistic interaction between antimony compounds and halogen-containing flame retardants. It is generally believed that a key step is interaction of the antimony compound with a decomposition product from the organic halide additive, most probably hydrogen chloride. With the use of a heterogeneous Knudsen cell reactor in conjunction with the mass spectrometer, it has been shown that the reaction of the HCl gas with antimony trioxide, at temperatures readily attainable in burning polymer systems, leads to the generation of antimony trichloride, $SbCl_3$, as the only volatile antimony-containing species. Antimony trioxide itself is essentially involatile at these temperatures. This reaction thus provides the means by which antimony can be transported into the vapor above a heated polymer.

Detail of the experimental arrangement for flame studies with the mass spectrometer systems. A premixed hydrocarbon flame is shown impinging on a quartz cone system; the reaction zone appears as a clearly defined, bright, conical region in the flame.

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NBS 1971
AN OVERVIEW

In September 1971 the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics conducted a series of Oversight Hearings on NBS. The objective of the Hearings was to present the Committee with an in-depth, timely review of NBS, its goals, structure, operations, strengths, and problems and opportunities. Testimony was presented during the Hearings by Bureau management, joined by Dr. A. V. Astin, former Director of NBS; Nathan Cohn, Executive Vice President, Corporate Development, Leeds and Northrup Co.; and Vico E. Henriques, Director of Standards, Business Equipment Manufacturers Association.

Following is a condensation of the testimony presented by NBS Director Lewis M. Branscomb. The complete testimony presented by all of the witnesses is available.

This is the first comprehensive legislative oversight examination of the National Bureau of Standards by this Committee. The need for such hearings is amplified by the swift changes overtaking the Bureau as it attempts to respond to demands placed on it by public needs, established in new legislation, or reflected in changing national circumstances within our original statutory responsibilities.

The basic enabling legislation established in 1901 and amended several times, most comprehensively in 1950, establishes the main purposes and authorities of the Bureau as follows:

> the custody, maintenance and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards including the comparison of standards; the determination of physical constants and properties of materials . . . of great importance to scientific or manufacturing interests . . . not to be obtained of sufficient accuracy elsewhere; the development of methods for testing materials, mechanisms, and structures and the testing of materials, mechanisms, and structures; cooperation with other Government agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications; advisory service to Government agencies on scientific and technical problems; and invention and development of devices to serve special needs of the Government.

Examination of this statute will show that NBS has both unique and special responsibilities in relation to the Nation's science and technology, and very broad responsibilities as well.

Our cornerstone responsibility is to provide for the United States the single authoritative source of accurate, compatible, and useful physical measurements and further to ensure their international compatibility. No nation in the modern world, much less the world's leading scientific and technological society, can prosper and function effectively if the national system of measurement is in a state of anarchy.

A nation cannot have two sizes for the inch, two weights for the pound or two values for the units describing electric power, temperature, frequency, time, or any of the 40 or more derived units and their many useful combinations. Only one laboratory can speak for the na-

tion in the international community of metrologists who work together under the aegis of the Treaty of the Meter to produce a single, compatible world system of measurement units. The laboratory with this responsibility must be above suspicion in its integrity, its competence, and its independence from influences. It must be devoted entirely to objective technical truth for it must be able to resolve conflicts when two people—or two companies—measure the same thing and get different answers. These principles are the life blood of the National Bureau of Standards and are strongly and deeply felt by each of our professional staff members.

THE PRICE AND VALUE OF ACCURACY

Accuracy is expensive and sometimes difficult to achieve. We put a lot of effort into discussing the needs of our "customers"—of American scientists, engineers, and businessmen and other Government officials—to be sure they really need the accuracy of measurement they say they must achieve. We believe that very large sums of money, reflecting countless engineering manhours, can be saved by adopting the philosophy: "Ask for no more accuracy than you need and be sure you get it."

MEASURES IN THE MARKETPLACE

If a free-enterprise economic system is to thrive in a modern industrial society, indeed if it is to survive, buyers and sellers in the marketplace need to have as much confidence in the quantity and performance of goods exchanged as they do in the amount of monies paid. A substantial part of the Bureau's measurement research is devoted to the validation of fair, objective, and useful measurement methods for application to both durable and nondurable goods in trade.

The commercial life of this country depends upon the Bureau's help with such measurement problems, because both buyer and seller need an unbiased, honest third party with the technical capability to say "This measurement is a fair and accurate one; that one may not be." Industry values the Bureau's third-party independence and integrity. The ADX2 case was of enormous significance to the National Bureau of Standards. It demonstrated that the Bureau does not shy away from technical problems of apparently low sophistication and potentially high controversy if they are important to the proper functioning of government, to the progress of science, or to the survival of the free enterprise system. It also demonstrated to every NBS scientist at that time and since that dedication to properly documented, objective, technical truth will result in the laboratory's vindication.

NBS GOAL: MAKE SCIENCE USEFUL

A laboratory of this type, with a 70-year tradition of scientific excellence and integrity, finds itself not only in great demand but acquiring additional major responsibilities that go far beyond the specific research requirements for the national system of measurement. We were established by the Congress to be helpful, and we find ourselves a critical link between the basic research community and those who have put science to work for the benefit of man. As the decades have passed, the Bureau has responded to the country's problems as they arose, in war and in peace, in times of rapid scientific growth, in times of scientific retrenchment and serious domestic problems. Throughout the thousands of useful projects at NBS runs a common thread: *the Bureau helps others with applied research services to produce, diffuse, and enhance the value of practical knowledge. Our goal is to strengthen and advance the Nation's science and technology and to facilitate their effective application for public benefit*—in short to help make science useful and technology the servant and not the master of people. To achieve this goal the Bureau integrates its scientific and technological activities and gives special attention to the public and private institutions through which our applied research services will benefit people. We do not just assume that our research will prove helpful to others; we do what it takes to insure that it is.

NBS RELATIONSHIPS WITH THOSE WE HELP

It is important that I say a few words about how NBS insures that our work reaches the hands of those it is meant to serve and how it insures that the benefits intended for the public are actually realized.

Government Agencies. The Congress has wisely chosen a statement of the Bureau's mission broad enough to allow the Bureau to respond to changing needs. By the same token, such a freedom of choice demands of us a continual appraisal of the most important problems to tackle. Of the criteria for choice, and therefore for action, four seem to be vital to success:

(1) needs in relation to our statutory mission;
(2) a timely technical opportunity;
(3) adequacy of resources in manpower and facility;
(4) availability of dynamic leadership.

Unless all these four criteria are met any problem that is tackled is not likely to have striking success.

Thirty-eight percent of all the funds expended by NBS are transferred from other agencies in reimbursement for technical and research services. These services range from brief consulting tasks, often offered without reimbursement; to special tasks of days or weeks duration; all the way to formal continuing agreements to provide very substantial resources to

another department of government.

State and Local Governments. Our ties with State and local governments are also of vital importance to our usefulness and effectiveness. Our prime strategy has been a consistent one—to preserve the constitutional prerogatives of the States by seeking to bring them together into national conferences for specific problems so that we can provide our technical help fairly and effectively to all 50 States and, at the same time, promote compatibility between the regulations and practices of the States where this is clearly to the Nation's advantage.

The first example of this relationship was brought into being almost immediately after the founding of the National Bureau of Standards in 1901. At that time the weights and measures regulations of the States were in chaotic condition. NBS Director Stratton brought into being the National Conference of Weights and Measures, which today is a strong and technically competent organization of State weights and measures officials, working in close harmony with industry and consumer groups and the National Bureau of Standards.

It is this model that we are following in our encouragement of the National Conference of States on Building Codes and Standards, seeking reform of the regulatory system for building construction. The States have very limited technological resources available to them, and it would obviously be wasteful if all 50 States had to establish parallel research capabilities. It is a logical, economical, and proper relationship for State officials to look to the NBS as a source of sophisticated technical help, drawing on the entire Nation's scientific and engineering capabilities.

ACADEMIC AND INDUSTRIAL RELATIONS

NBS relationships with the academic and industrial research community have always been very close. These relationships are most effectively established through participation of our scientists and engineers in the professional societies, the major private sector standards organizations, and by direct collaboration in joint research projects both with university scientists and with industry.

For academic and other scientists attempting the most sophisticated and demanding scientific research, we offer our talents and facilities on a cooperative basis. There are many physics experiments that simply cannot be done without direct access to our standards, our laboratory environment, and our talented staff.

We are particularly proud of our industrial Research Associate Program through which industrial firms, at their own expense, send top scientists or engineers to NBS for a program of jointly selected research.

INTERNATIONAL RELATIONSHIPS

Finally, I must say something about our international responsibilities and relationships. As the world's leading technological nation the United States has a vital interest in insuring that the world system of measurement is not only internationally compatible but also is sufficiently sophisticated to meet United States needs. NBS helps assure this through our relationships to the General Conference of Weights and Measures, a triennial international diplomatic conference established by the Treaty of the Meter in 1875. The success of United States foreign commerce, as well as the success of international scientific cooperation, depends upon the continued progress of this cooperative international endeavor.

Because of our special interest in applied science and in applied research services for economic development, nations at all stages of development have expressed great interest in NBS. The recent visits of two senior staff members of the national metrological laboratories in Romania result from high-level diplomatic initiatives by the United States leading to bilateral cooperative agreements in science and technology.

MAJOR GOALS AND OBJECTIVES

The chart shows the six major goals and objectives of the Bureau of Standards. They describe not only what we do, but through what groups and institutions we work in order to achieve the desired results.

Measurement Services for Science and Technology
Science and Technology for Industry and Government
Technical Services for Equity in Trade
Technical Services for Public Safety
Technical Information Services
Central Technical Support

The first program helps scientists and engineers make *accurate, meaningful, and compatible measurements* and *provides* them with *data needed in research* and *engineering.* Among the programs listed under this heading are quite a number that are concerned with transferring into the user's laboratory the measurement standards or the measurement capabilities realized at NBS. This is the traditional way to transfer measurement accuracy. Increasingly we are finding that time and money can be saved and measurement accuracy and confidence improved if the Bureau can provide the scientist or engineer with a self-calibration capability.

Our services for industry and government are largely concerned with helping others make more effective use of science and technology

in their achievement of identified priority goals. Many of these programs are designed to apply research to the elimination of barriers that inhibit the private sector, or the rest of government, from the most effective use of science in the public interest. The Bureau of Standards is not in competition with industry. We do not develop products or processes. We do solve problems of general concern, provide technical data and useful knowledge and participate, as an unbiased expert in the development of voluntary industrial and data processing standards. Our purposes are to promote fair competition, improve productivity in research, production and delivery of services, assist regulatory officials with objective, rational standards setting and look for ways to release the innovative energies of this great nation to use technology to solve its problems.

Earlier in this testimony I referred to the importance of measurements used in commerce to the maintenance of confidence in a free enterprise economy. Programs of this type are conducted under the heading, *Technical Services for Equity in Trade.* Important among these is NBS participation in voluntary engineering and information processing standards activity. A healthy and effective national standards program can promote innovation and improve productivity in industry, and can provide the small businessman with a better opportunity to break into an established market or to bid on components and materials subcontracts. It can save millions of dollars in the writing of technical specifications for competitive bids and can improve the standards of industrial practice throughout our Nation. Since the system is a voluntary system, established in the private sector, it is sometimes disappointingly slow and occasionally even operates to impede commerce or competition. There is frequently a need for public interest representation at the standards negotiating table. It is uneven in its technical quality and suffers from the lack of both financial and scientific support from both industry and government. But without a continually updated set of tens of thousands of standards prepared by sector organizations we would either have to revert to a preindustrial society, or establish the standards by decree as they do in many communist countries.

PRODUCT PERFORMANCE

We do *not* test consumer products at the request of either manufacturers or consumers. We believe that a free market is the best determinant of overall relative quality for consumer products. However, both industry and consumer advocates agree that the interests of all would be served by engineering progress in the development of criteria and methods for evaluating those types of product characteristics that are important to public safety and welfare, and that lend themselves to objective technical measurement.

With respect to safety programs, the Bureau works on problems assigned to us in our enabling legislation dealing with fire research and safety, on problems assigned to us by special statutes such as the Flammable Fabrics Act, and the Refrigerator Safety Act and, in collaboration with other agencies, in other fields where safety research and standards are needed. NBS has given a very high priority to implementing our responsibilities under the Flammable Fabrics Act. Our 1972 Flammable Fabrics expenditures will be over 10 times the budget level of 1969. But in spite of considerable progress in that field, we have made only a modest initial effort in tackling the whole fire problem.

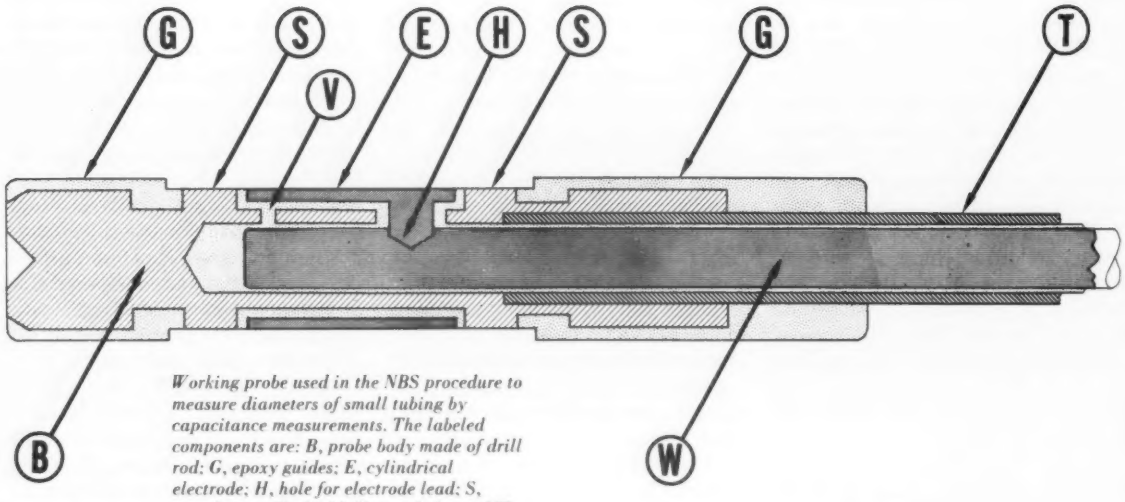
SPECIAL PROBLEMS AND OPPORTUNITIES

During a time of rapid priority change and laboratory reorganization, our staff has proved admirably adaptable. Still, an annual reduction-in-force averaging about 1-1/2 percent of our total personnel in each of the last 2 fiscal years has been regrettable, but unavoidable.

At the same time, we have permitted the state of the Bureau's equipment to fall far below the standard to which industrial laboratories maintain themselves, notwithstanding the fact that it is our responsibility to be the measurement reference laboratory for them. We have also seen severe attrition in discretionary operating funds over and above our basic technical and support payroll. This, in part, has forced the reductions-in-force as managers reduce staff to keeping operational efficiency.

Despite these difficulties I believe the National Bureau of Standards faces the most challenging opportunity of any large research laboratory in this Nation. We have the right competence in the right organization at a right time. We are effectively engaged in a way that I think is unique in bringing science and technology to bear on national social and economic problems as well as on our scientific advancement. Our scientists understand the complexities of the social context within which their research must find application. We enjoy a generally excellent reputation among those who know our work, even though we have not been very active in making ourselves known to the general public.

I am deeply concerned that disillusionment may follow if government fails to promote innovation and the productivity of our technology and fails to guide the regulation of technology on the basis of objective evidence and fair and accurate measurements. We see the national measurement system and a system of industrial and engineering standards as dynamic systems calling not for more stewardship, but for leadership.



Working probe used in the NBS procedure to measure diameters of small tubing by capacitance measurements. The labeled components are: B, probe body made of drill rod; G, epoxy guides; E, cylindrical electrode; H, hole for electrode lead; S, guard rings; T, shield; V, vent hole; and W, wire coaxial lead.

IMPROVED METHOD FOR MEASURING DIAMETERS OF SM

A NEW METHOD FOR MEASURING THE DIAMETERS OF SMALL-BORE METAL TUBING HAS BEEN DEVELOPED IN THE INSTITUTE FOR BASIC STANDARDS.[1] In this work, by R. E. Edsinger, L. A. Guildner, and R. L. Anderson of the Heat Division, capacitance measurements between the tubing and a cylindrical coaxial probe of known characteristics are used to determine diameters with an estimated overall uncertainty of 0.6 μm over lengths of 1 metre. The increased accuracy of the technique should make it extremely valuable in thermometry, manometry, rocketry, nuclear power generation, and other fields where accurate knowledge of the volume of flows is necessary.

The NBS technique is based on capacitance measurements, using the tube and probe as the electrodes of a three-lead capacitor, which can be measured with high accuracy in a transformer ratio-arm bridge. With this method, a "calibrating probe" is used to measure the diameter of a "standard hole," and a "working probe" functioning as a transfer device is used to measure the tube itself. This arrangement permits the use of a very precise (but delicate) probe to calibrate the standard hole and allows a sturdy, stable probe to be used for tube measurements.

In the NBS procedure, the diameter of the standard hole is determined by two capacitance measurements. First, the capacitance of the calibrating probe in the standard hole is determined. Next, an extension is affixed to the probe and another capacitance measurement is made. The difference of these measurements effectively eliminates the uncertainties in capacitance due to end effects associated with the probe geometry. The diameter of the hole can then be calculated from the diference of capacitance by taking into account the dimensions of the extension and the dielectric constant of air.

The diameter of the working

The working probe and a tube to be measured are shown here magnified approximately 26 times (tube diameter is 0.91 mm). The light bands on the ends of the probe are epoxy guides, which keep the probe centered in the tube.

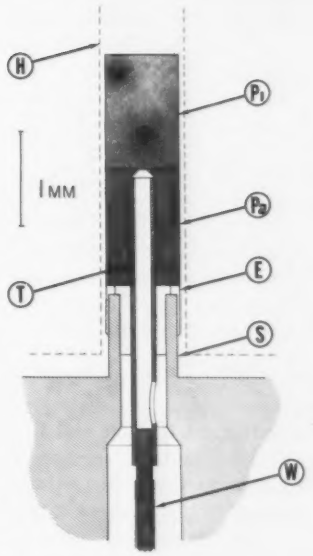
OF SMALL-BORE METAL TUBING

probe is then determined by capacitance measurements in the standard hole. Next, the working probe is drawn coaxially through the tube to be measured and the capacitance recorded on a strip chart. From these measurements of capacitance, the diameters of the tube as functions of position can be calculated.

In the NBS experimental work, a standard hole was drilled on the axis of a 25-mm-diameter brass rod. The hole was reamed and lapped to a mirror finish with a taut cotton string loaded with diamond-lapping paste. The straightness, uniformity, and circularity of the standard hole were determined from measurements of the capacitance between it and an "analyzing probe." For this purpose, the standard hole was placed in a specially designed fixture which allowed the standard hole to be tilted, rotated, and centered with respect to the probe. From the capacitances between a tiny electrode of the analyzing probe and parts of the wall of the standard hole, it was possible to select a portion of the hole to be calibrated which was uniform, straight, and round, each within 0.25 μm.

The calibrating probe consisted of a cylindrical "base block" with a base and leads, and another cylin-

Continued on page 16



Calibrating probe used to measure capacitance of a "standard hole." The probe consists of two cylindrical blocks (P_1) and (P_2), together with base (S) and lead (W). Other components are: T, inconel tube; and E, epoxy to hold sleeve.

NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

IMPORTANCE OF CRITICALLY EVALUATED NUMERICAL DATA

Excerpts from a statement by Lewis M. Branscomb, Director, National Bureau of Standards, made on August 3, 1971, at the hearing before the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, Ninety-Second Congress.

"The quantitative facts about nature on which both progress and usefulness of science depend are recorded in scientific literature as numerical data about the properties of matter. Most of this data is not produced as the deliberate result of efforts to obtain accurate data for applications. Such programs are necessary, but they are slow and expensive.

"I would not want to startle any of the members of this distinguished Committee who might still believe in the infallibility of science, but I must confess that when scientists, or engineers too, make a measurement in the laboratory, they do not always get the right answer. More specifically, since no measurement is perfect, they do not always get as accurate an answer as they claim to have, sometimes by a large measure. Usually this is because reliably accurate data was not the investigator's main purpose. Nor, when they write up their work for publication, do scientists always explain what they have done in clear enough language for other scientists to understand them and objectively evaluate their work. The result is that the scientific literature is filled with numerical data, some good, some bad, others of unknown quality. The scientist or engineer who wants to use one of these numbers must possess the right combination of skill and serendipity in order to choose the best one. And the prolific output of the world's scientists, with their up-to-date instruments and faster computers, makes this problem worse every year.

"The reason, of course, that we want to have the good results evaluated and compiled is that numerical data on important properties are useful for many applications in addition to the one that induced the original measurement. You need to know some of the same properties of tungsten whether you are making a razor blade or a light bulb, and these properties may have been measured by someone who had no interest in either razor blades or light bulbs. If you can find a reliable value in a handbook, you don't have to go into the laboratory and measure it yourself or trust your luck in a value found by a laborious search through the literature.

"There is another reason for finding out how good the measurements in the literature are. Scientists don't want to produce unreliable data; they continue to improve their methods when deficiencies are pointed out. But critical self-examination does not necessarily come more easily to scientists than to other humans. It often takes a detached expert, looking objectively at the work of many different scientists, sometimes representing different disciplines, to pick up a major source of error which no one had taken into consideration before. Once these pitfalls are recognized and widely publicized, most scientists will take due care in avoiding them. Those who do not rapidly lose credibility among their peers and, hopefully, the support of their sponsors.

"It is certainly unnecessary to remind this Committee of the size of the national investment in research and development. A small increase in productivity or reliability of research output can enhance by a very large amount the dollar benefits resulting from this investment. In the fields of physics, chemistry, and related engineering disciplines, which are responsible for generating most of the data falling within the scope of the Standard Reference Data Program, the annual funding of basic research alone by the Federal Government is at least $600 million. This amount of money generates large quantities of physical and chemical property data which are buried in 30,000 or more scientific papers published each year. These data represent one of the major benefits of that $600 million investment in basic research. A primary aim of the

Standard Reference Data Program is to improve the effectiveness of that investment, first by selecting the best of the data and making them available for all to use, and, second, by upgrading the quality of future measurements.

"There is another important factor to consider. The output of American scientists represents less than 30% of the world's research in these fields. If the other 70% can be made available for use by our own scientists and engineers, it will not be necessary for us to spend the money to do these measurements. However, it is hard enough to know how much confidence to place in measurements done by one's own friends and associates; evaluation of data obtained in other countries, usually with unfamiliar instruments, and often reported in a foreign language, is a very difficult task. The Standard Reference Data Program undertakes this job in a systematic and efficient manner, retrieving data from the entire world literature and subjecting them to critical standards of evaluation."

NBS ALLOY DATA CENTER AUTHOR INDEX

NBS-OSRDB-70-2, *The NBS Alloy Data Center: Author Index*, by G. C. Carter, D. J. Kahan, L. H. Bennett, J. R. Cuthill, and R. C. Dobbyn[1] (COM-71-00722, Hard Copy $10, Microfiche 95 cents) was recently published for inclusion in the NBS Office of Standard Reference Data Bibliography Series by the National Technical Information Service.

This Index contains literature references to 12,000 research papers on physical properties of metals and alloys. It was created from the "Biblio-Master-File," a computer tape containing the master file of the NBS Alloy Data Center. The material has been arranged in accordance with three categories of properties. The first contains all NMR Knight Shift papers and many other papers dealing with NMR, NQR, FNR, and other nuclear resonances in metals. This section is complete for the period 1949-1969 and contains several 1970 papers. The second contains all soft x-ray emission papers since 1940 as well as some earlier papers and many soft x-ray absorption papers. The third section represents papers of general interest to the Alloy Data Center, on related topics such as Mössbauer effect, susceptibilities, specific heats, hyperfine fields and band structures. This section does not represent a complete set of such papers. The referenced papers are annotated in depth and coded information (journal citation, physical properties, material studied, material composition, and temperature) was put onto the Biblio-Master-File. The Author Index was created from this tape, listing each paper under first author. The full annotation of each paper is given in the reference. For each metal or alloy system reported in a paper, a separate line appears in the Index.

The Biblio-Master-File can be manipulated in a number of ways with various available computer programs. A related publication developed from one such manipulation is NBS Special Publication 324, *The NBS Alloy Data Center: Permuted Materials Index*, by G. C. Carter et al.[2] (SD Catalog No. C13.10:324, $7).

BIBLIOGRAPHY OF GAS PHASE REACTIONS OF N_2, O_2 AND NITROGEN OXIDES

NBS-OSRDB-71-2, *A Bibliography of Kinetic Data on Gas Phase Reactions of N_2, O_2 and Nitrogen Oxides*, by Francis Westley[1] (COM-71-00841, Hard Copy $3, Microfiche 95 cents) is the latest publication in the NBS Office of Standard Reference Data Bibliography Series published by the National Technical Information Service.

This Bibliography lists papers and reports on the gas phase reaction kinetics in the nitrogen-oxygen system through 1970. Only reactions among N, N_2, O, O_2, O_3, and the nitrogen oxides are considered. The material is presented in two methods: by reaction, with a listing of each pertinent article; and in a general reference list, which has been arranged alphabetically by first author.

The articles included have been selected from the files of the Chemical Kinetics Information Center. The criterion for inclusion of an article was that new information on the reaction was available, when the article in question was compared with the chronologically preceding ones. That is, simple quotations of the results of others and *ad hoc* guesses have been excluded. There are gray areas, of course, such as the statement of a rate calculated from that of the reverse reaction and the equilibrium constant, or mechanistic information. Over 900 papers are listed.

BIBLIOGRAPHY ON ATOMIC TRANSITION PROBABILITIES

NBS Special Publication 320 Supplement 1, *Bibliography on Atomic Transition Probabilities July 1969 Through June 1971*, by J. R. Fuhr and W. L. Wiese[2] (SD Catalog No. C13.10:320, 65 cents, Suppl. 1) is the first supplement to NBS Special Publication 320[2] ($1.25, SD Catalog No. C13.10:320), which covers the literature on atomic transition probabilities received by the NBS library from July 1969 through June 1971. The number of articles containing numerical data or important reviews or comments of general interest in this area has increased by about 300 from the 1,377 previously listed. The present supplement contains references to all these new papers, plus a few older ones that were inadvertently omitted in the original publication. The items in the supplement are arranged, as before, according to elements and stages of ionization; the method employed

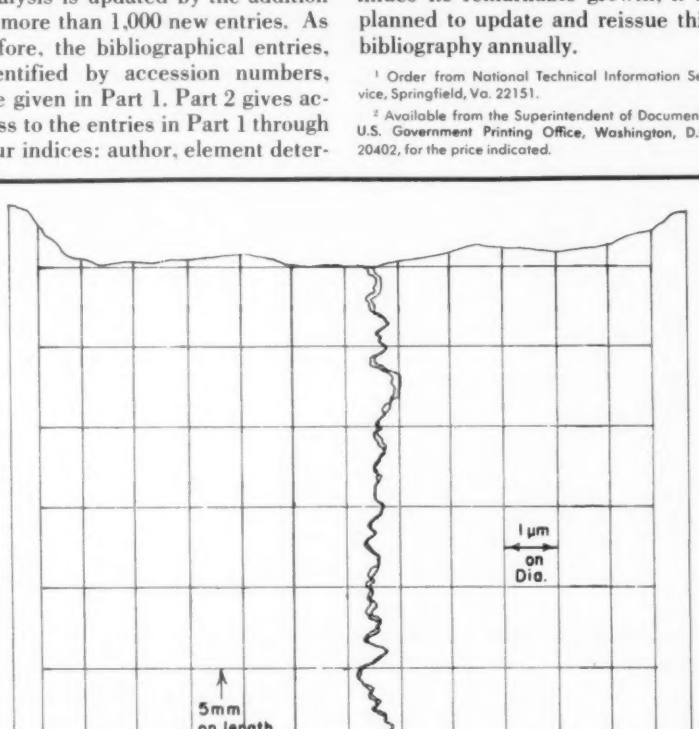
and classification of transitions are indicated for each reference. Only articles on discrete transitions, both allowed and forbidden, are listed. To keep the bibliography to a reasonable size, papers containing data for many elements within isoelectronic sequences are collected separately in front of the list.

ACTIVATION ANALYSIS BIBLIOGRAPHY

NBS Technical Note 467, *Activation Analysis: A Bibliography*, edited by G. J. Lutz, R. J. Boreni, R. S. Maddock, and W. W. Meinke ($5.25, SD Catalog No. C13.46:467/1971) supersedes previous editions (issued in 1968 and 1969). This present version of the NBS bibliography on activation analysis is updated by the addition of more than 1,000 new entries. As before, the bibliographical entries, identified by accession numbers, are given in Part 1. Part 2 gives access to the entries in Part 1 through four indices: author, element determined, matrix analyzed, and technique utilized. Since the literature of activation analysis (chemical analysis based on detection and measurement of the radiation produced when a sample is bombarded by nuclear projectiles) continues its remarkable growth, it is planned to update and reissue this bibliography annually.

[1] Order from National Technical Information Service, Springfield, Va. 22151.

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.



Two strip chart traces representing two runs, one with the tube rotated 180°, in the measurement of small metal tubing. Using such capacitance measurements, diameters as a function of position can be determined with an estimated probable error of 0.6 μm in tubes with lengths of 1 metre.

DIAMETERS *Continued*

drical block of the same diameter, the "probe extension." The blocks were fabricated from 0.844-mm-diameter steel drill rod. The end of the base block was finished flat as determined by an interferometer. The probe extension was also lapped until its ends were flat and parallel so that it could be wrung to the end of the base of the probe.

The working probe was designed for sturdiness and stability, and in such a form that a simple and reliable equation could be used for its capacitance. It was fabricated from drill rod in the form of a cylindrical electrode with end guards. Guides for centering the probe for measurements were made by allowing liquid epoxy to harden on each end and turning the epoxy ends down with a lathe to fit the tube.

For best results the standard hole should be approximately the same diameter as the tube to be measured. Thus it would be necessary to construct a set of standard holes to measure a wide range of tube diameters with highest accuracy.

[1] Edsinger, R. E., Guildner, L. A., and Anderson, R. L., Measurement of internal diameters of long, small-bore metal tubing, Rev. Sci. Instr. **42**, 945 (Aug. 1971).

HIGH PRESSURE *Continued*

Antimony trichloride is also formed by the thermal decomposition of antimony oxychloride, SbOCl, which is itself effective as a flame retardant and which has been suggested as a key intermediate in the chemistry of the antimony-chlorine synergism. A study of the rate at which $SbCl_3$ is evolved from the oxychloride shows that the latter decomposes in a series of steps involving successive formation of several oxyhalide compounds in the solid phase. This study confirms, by direct measurement of the volatiles, inferences of other workers based on thermal analysis. The stepwise degradation of antimony oxyhalides has the effect of "spreading out" the evolution of $SbCl_3$ over a relatively wide temperature range, a fact which may be significant in making the antimony-halogen system applicable to flame retardancy in a variety of different polymers having different decomposition temperatures.

To study the chemistry of antimony additives in flames, the mass spectrometer was used to measure concentrations of important species at various points in the premixed methane-oxygen laminar flow flame. Antimony trichloride was introduced by passing the fuel-oxygen mixture over $SbCl_3$ before it entered the burner. Flame sampling with the mass spectrometer showed that the chemistry of the preflame region was characterized by relatively high concentrations of $SbCl_3$ species and also by a number of Sb_4O_6 molecules and chlorine atoms. These concentrations were found to diminish near the luminous-reaction zone and product species such as HCl, CH_3Cl, SbO, and Sb were formed. It was found that some compounds, such as CH_3Cl and HCl, reached their maximum levels somewhat "upstream" of the reaction zone in the burner flame. This was even more pronounced with the corresponding bromides when $SbBr_3$ was used as the antimony source. In contrast, Sb and SbO appeared to maximize at the reaction zone itself as did the radical species H, OH, and CH_3.

The mass spectrometric flame-probe studies indicate a relatively complex chemistry in burning systems containing antimony additives and suggest several possible mechanisms for the synergistic function of antimony in flame retardancy. It is clear that the presence of antimony provides a means for controlled release of halogen from a pyrolyzing substrate into the vapor phase through formation of volatile antimony halides. The data also show, however, that with both antimony and halogen present, Sb_4O_6 is an important constituent of the preflame zone under conditions where antimony trioxide in the substrate is itself not appreciably volatile. It is suggested that this species may provide additional retardancy through third body radical recombination mechanisms. Such mechanisms may possibly involve the species HO_2 which has been found to be present in the preflame zone of hydrogen-oxygen flames.

The species HO_2 was observed in 1 atmosphere H_2-O_2 and H_2-O_2-N_2 flames and its flame concentration profile compared with those of H, H_2, O_2, H_2O and the temperature. The results indicate that HO_2 reaches a steady state maximum concentration very early in the preflame region. Any factor which results in the loss of H atoms, such as the formation of HO_2, can also provide a means for flame inhibition.

[1] Hastie, J. W., Mass spectrometric study of HO_2 in 1 atm. flames, to be published.

[2] Hastie, J. W., Mass spectrometric studies of flame inhibition—the antimony oxyhalide system, a talk presented before the ACS National Meeting in Washington, D.C., Sept. 16, 1971.

KILOWATT-HOUR *Continued*

in service likewise requires very stable standards in the meter laboratory. In addition, independent means of verifying the accuracy of house-type meters as they are installed are needed to insure fairness to both customer and the power company.

In this same program, NBS is improving its master watt-hour meters and its methods of calibrating portable standard meters as well as developing new and more accurate standards and calibration methods. This cooperative study will enable power companies to take advantage of these developments with a minimum time lag.

In this pilot study Mr. Houghton will establish the accuracy and stability of a group of portable standard watt-hour meters and take them to selected power companies. The companies will then calibrate the meters with their standards. Statistical procedures worked out in cooperation with NBS will be used to analyze the results. He will then investigate the possibility of using such interlaboratory or round-robin tests to establish the kilowatt-hour in meter laboratories and to maintain it by periodic shipments of meters of known characteristics and stability. Studies of new types of electronic watt-hour meters will also be carried out, as well as the feasibility of interlaboratory tests of highly stable house-type meters to evaluate the overall accuracy of meter laboratories.

This program is one of a number of research-associate projects[1] at NBS by which scientific or industrial organizations use the Bureau's facilities to perform research in areas of mutual interest that will benefit the public directly or indirectly.

[1] NBS broadens collaboration with industry, Nat. Bur. Stand. (U.S.), Tech. News Bull. **50**, No. 2, 26-28 (1966).

RADIOPHARMACEUTICALS

NBS STUDIES RADIATION PENETRATION IN SIMULATED BODY TISSUES

IN RECENT YEARS THERE HAS BEEN A RAPID INCREASE in the use of radioactive drugs (radiopharmaceuticals), which are now administered annually to several million people in the United States for medical purposes. While substantial medical benefits result from the use of radiopharmaceuticals, concern still exists about the risks resulting from the absorption of nuclear radiations within the body. At the NBS Center for Radiation Research, physicists M. J. Berger and R. Loevinger are engaged in research and critical data tabulations pertinent to the radiopharmaceutical safety problem. This is done as part of their regular radiation transport and dosimetry research program, and through participation in the work of the Medical Internal Radiation Dose (MIRD) Committee of the Society of Nuclear Medicine.*

Radiopharmaceuticals, administered either orally or intravenously, often can be traced through the body by employing external detectors close to the body surface to detect emitted gamma rays. In this manner physicians can follow the movement through the body to determine the rate of metabolic processes, and to check the functioning capabilities of various organs.

While enough radiation may leave the body to permit tracing of the radiopharmaceutical, some radiation is absorbed internally by tissues and organs. This "absorbed dose" is potentially harmful and should be kept to a minimum. Radiologists must have adequate information about the absorbed-dose distributions in the body, so that they can weigh the medical benefits against the risks of radiation injury.

The problem of absorbed-dose determination falls into two parts. First, the distribution of the radionuclides must be known as a function of time and position in the body, taking into account the radioactive decay laws as well as the movement of the drug through the body via biological processes. Second, the absorbed-dose distributions corresponding to various radionuclide source distributions are determined by including in the computation the energy, penetration depth, and diffusion of the emitted radiations, and the density of the absorbing tissues.

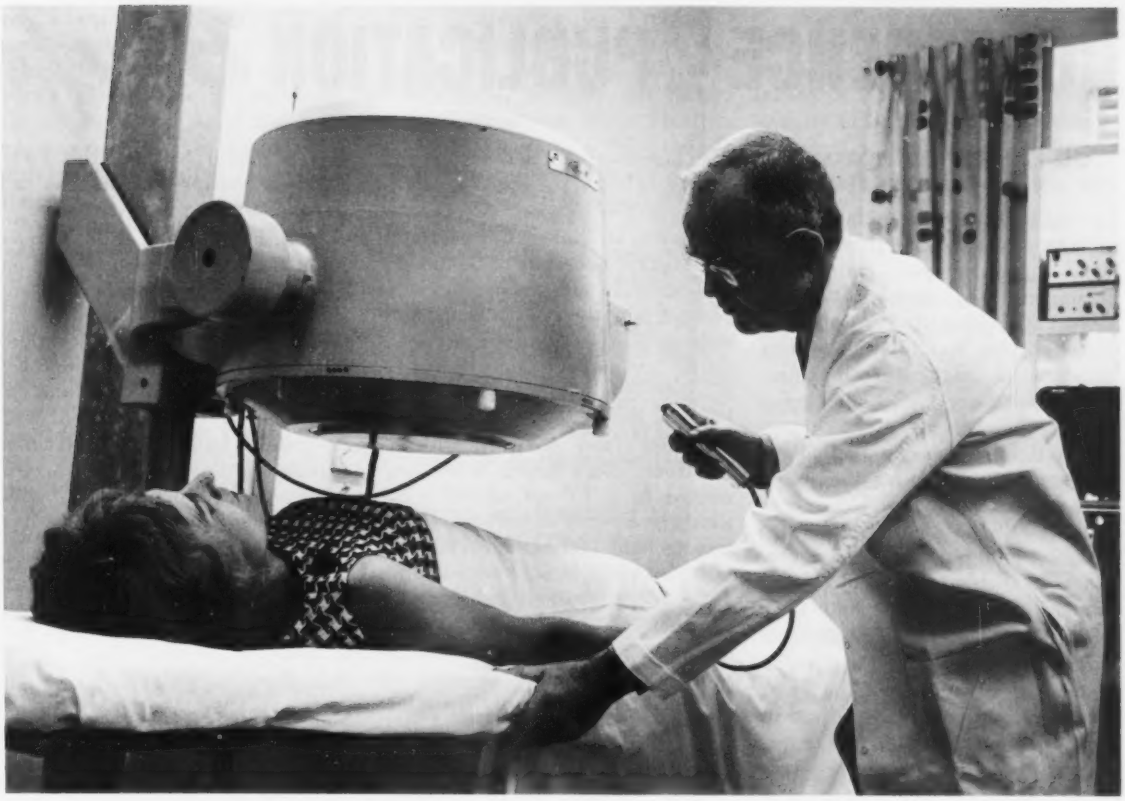
Dr. Loevinger, in collaboration with M. Berman of the National Institutes of Health, has developed a formalism[1-3] by means of which the whole complex of physical and biological factors is organized. This formalism has been adopted by the MIRD Committee as the organizing framework within which biologists and physicists provide their contributions.

Dr. Berger has contributed electron, beta-particle, and gamma-ray penetration data needed for absorbed-dose estimates. These data were generated by general theoretical-transport calculations (the moment and the Monte Carlo methods), developed in the fifties and sixties at NBS by Spencer, Fano, and Berger,[4-8] as contributions to the U.S. atomic energy and space programs. In order to make them applicable to medical technology, a good deal of "translation," further development, and numerical evaluation was needed.

The output of this work consists of so-called point kernels, which describe the distribution of absorbed doses around point isotropic sources that emit radiation uniformly in all directions. These distributions have been calculated and carefully checked by comparison with experimental data. Point-kernel data have been obtained for monoenergetic photons[9] at energies between 15 keV and 2 MeV, for monoenergetic electrons at energies between 25 keV and 4 MeV, and for 75 beta-emitting radionuclide sources where water and tissue were assumed to be the absorbing media.[10]

The point-kernel results have a rather general applicability. Because of the linearity of the transport process, absorbed-dose distributions can be obtained for any spatial-radionuclide-source distributions by carrying out appropriate integrals over the point kernels weighted by the appropriate spatial-source density. In other

*The MIRD Committee is a cooperative enterprise including physicists, biologists, and physicians, and is supported by the U.S. Public Health Service.



A continuing program is underway at NBS to assist the medical field by determining the energy distribution of beta particles and gamma rays in simulated body tissue. This information will be helpful to radiologists such as the doctor shown here at the NIH Clinical Center taking pictures of radiopharmaceuticals distributed in a patient's body. The scintillation detector camera unit above the patient provides the doctor with a TV-like picture produced by detecting the radiation emitted by the drug within her body. Photo courtesy of the National Institutes of Health.

words, all transport phenomena resulting from the interaction of the radiation with the medium have already been accounted for in the point-kernel calculation. The remainder of the calculation is geometrical and only requires the routine evaluation of numerical integrals.[11]

The superposition of point-kernel results is adequate for source configurations in the body for which a homogeneous tissue can be assumed. Under conditions where tissue-density variations, or the presence of bones or voids in the body, are important, more elaborate and less general transport calculations must be made. A long-term program to this end, using the Monte Carlo method, is in progress in the Center's Radiation Theory Section.

For further details, see the following publications:

[1] Loevinger, R., and Berman, M., A schema for absorbed-dose calculations for biologically-distributed radionuclides, J. Nuclear Medicine, Supplement No. 1, Pamphlet No. 1, 7-14 (Feb. 1968).

[2] Loevinger, R., and Berman, M., A formalism for calculation of absorbed dose from radionuclides, Phys. Med. Biol. **13,** 205-217 (Apr. 1968).

[3] Loevinger, R., Distributed radionuclide sources, Radiation Dosimetry, Vol. III, Ed. 2, Chapter 18, 51-90 (F. H. Attix and E. Tochlin, Eds., Academic Press, New York, N.Y. 1969).

[4] Spencer, L. V., and Fano, U., Penetration and diffusion of x-rays. Calculation of spatial distributions by polynomial expansion, J. Res. Nat. Bur. Stand. (U.S.), **46,** 446 (1951).

[5] Fano, U., Spencer, L. V., and Berger, M. J., Penetration and diffusion of x-rays, Encyclopedia of Physics, **38II,** Springer (1959).

[6] Spencer, L. V., Theory of electron penetration, Phys, Rev. **98,** 1957 (1955).

[7] Spencer, L. V., Energy dissipation by fast electrons, Nat. Bur. Stand. (U.S.), Monogr. 1, 70 pages (1959).

[8] Berger, M. J., Monte Carlo calculation of the penetration and diffusion of fast charged particles, Methods in Computational Physics **1,** Academic Press, New York (1963).

[9] Berger, M. J., Energy deposition in water by photons from point isotropic sources, J. Nuclear Medicine, Supplement No. 1, Pamphlet No. 2, 17-25 (Feb. 1968).

[10] Berger, M. J., Distribution of absorbed dose around point sources of electrons and beta particles in water and other media, J. Nuclear Medicine, Supplement No. 5, Pamphlet No. 7, 7-23 (Mar. 1971).

[11] Berger, M. J., Beta-ray dosimetry calculations with the use of point kernels, Medical Radionuclides: Radiation Dose and Effects, and Loevinger, R., Some remarks on the MIRD schema for absorbed-dose calculations for biologically-distributed radionuclides, Proc. of a symposium held at Oak Ridge Assoc. Univ., U.S.A.E.C. Report CONF-691212 (June 1970).

CONFERENCE & PUBLICATION *Briefs*

TECHNICAL SERVICES WORKSHOP FOR ROCKY MOUNTAIN REGION

About 120 representatives of private industry, Federal, State, and local governments, educators, financiers, and members of the press gathered at the Denver Hilton Hotel on October 28, 1971, to hear specialists from the Bureau explain services that are available for noise and air-pollution research, computers and teleprocessing, technological forecasting, and time dissemination. Department of Commerce Field Office personnel also described the business service programs available from Field Offices in major cities across the Nation.

The audience came to listen for a variety of reasons. A representative of an auto-engine rebuilding company was particularly interested in measuring air pollutants and determining how these measurements related to new laws affecting exhaust emissions. He was also interested in the proposed conversion to metric measurements and how and when his operation would be affected. Private investors and bankers listened attentively for clues in technological forecasting that might affect future business policy. Professors and education administrators sought answers to questions concerning curriculum structure which will prepare students for a new world of metric measurements and environmental consciousness. Some of the government employees attending the meeting represented scientific diciplines that interface with the subjects discussed, while others were more interested in workable concepts of new laws to benefit their citizens; laws that could be equitably enforced with reliable measurements.

Featured on the program was a demonstration of a new system that transmits accurate time signals to most of the Nation via network television. Dr. Robert Cairns, Deputy Assistant Secretary of Commerce for Science and Technology, explained how the system would provide an inexpensive time and standard frequency for industry, science, medicine, and even the home. He presented Colorado Governor John A. Love with an electronic clock which, when connected to a TV set, decodes the time signals and displays the hour, minute, and second, accurate to a few thousandths of a second. For about $20, a similar circuit could be incorporated in new TV receivers at the factory to display the time in small numbers in the corner of the screen. These signals do not interfere in any way with normal programs, yet can be used to obtain time signals of better accuracy than most other systems provide at higher cost.

Dr. James Barnes, Chief of the Time and Frequency Division of the NBS Boulder Laboratories, outlined the various standard time and frequency services offered at present by NBS radio stations WWV/WWVH/WWVB/WWVL, and described some of the experimental services being studied, such as disseminating time by satellite and very-low-frequency radio waves.

Dr. Lewis M. Branscomb, Director of NBS, spoke on two subjects; after outlining NBS goals and programs, especially noting those of particular interest to the Rocky Mountain region such as Mine Safety, he reviewed the U.S. Metric Study completed by NBS at the request of Congress. The Secretary of Commerce has recommended converting most of our measurement system to metric units over a 10-year period, based on this study. Such a conversion process will depend on Congressional action.

D. R. Flynn, Chief of the Applied Acoustics and Illumination Section, presented an impressive film and sound demonstration of city and factory sound levels, and described NBS efforts to develop improved measurements of sound and its transmission. He also told of NBS programs in building research aimed at reducing the sound level in homes, apartments, offices, and other places where people work or live.

Dr. Ruth Davis, Director of the NBS Center for Computer Sciences and Technology, brought the audience up-to-date on the capabilities of computers and went on to describe some probable new applications. She told of the advancements being made in teleprocessing, or computer networking, to interconnect several computer systems and allow sharing of data and processing facilities. This would lead to more economical data processing as well as help us to tackle on an integrated and coordinated basis such nationwide problems as environmental damage.

Dr. James McNesby, manager of the Measures for Air Quality program in NBS, emphasized the fundamental truth that reliable measurements are necessary if there is to be any realistic control of air pollution. He described air quality measurements that are presently adequate and named some that still need development. He outlined NBS methods for making laboratory measurements that are useful to those charged with the responsibility for enforcing pollution laws.

Dr. Howard Sorrows, Associate Director of NBS for Programs, discussed technological forecasting

and its benefits. He briefly outlined some of the methods of predicting technolgical change from historical trends and existing relationships, and observed that such forecasts can materially help in the development and evaluation of plans, strategies, and objectives.

From these discussions and the question-answer periods that followed, participants at the meeting gained a better understanding of what NBS is trying to accomplish and how NBS can help them in their work. They also learned where to go for more information and help on specific problems, not a small thing in view of the size of the Federal establishment these days.

CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS

THE 1972 CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS (CPEM) will be held June 26-29, 1972, Boulder, Colo., laboratories. The CPEM is held every other year and the goal for the 1972 CPEM is the advancement of electromagnetic measurements science and measurement technique which are critical to technology and beneficial to society.

The conference is international in scope and will include a special session on international comparison of new electromagnetic techniques in length metrology. Each session of the 3-day conference will begin with an invited review paper to give perspective of the state-of-the-art for a particular area of measurement.

Sessions planned for 1972 include radiation safety (RF, microwave, and laser); automated measurements; measurement applications in biomedicine, air pollution, process control, network analysis, etc.; time and frequency measurement; direct current and low frequency measurement; microwave measurement; and measurement of pulse quantities.

The Conference on Precision Electromagnetic Measurements is sponsored by the National Bureau of Standards, Institute for Basic Standards; the Institute of Electrical and Electronics Engineers, Group on Instrumentation and Measurement; and the International Scientific Radio Union, U.S. National Committee. A cooperating sponsor is the Union Radio-Scientifique Internationale. The CPEM will follow the June 21-23, 1972, Joint Measurement Conference also being held at NBS in Boulder, Colo.

For further information, contact D. F. Wait, 1-4655, National Bureau of Standards, Boulder, Colo. 80302.

PRECISION MEASUREMENT AND FUNDAMENTAL CONSTANTS

Precision Measurement and Fundamental Constants Proceedings of the International Conference held at the National Bureau of Standards, Gaithersburg, Md., August 3-7, 1970, edited by D. N. Langenberg (University of Pennsylvania) and B. N. Taylor, NBS Special Publication 343, issued August 1971 ($6, SD Catalog No. C13.10:343).

As the editors remark, the main reason for the persistent efforts towards greater accuracy in the determination of fundamental physical constants is that they "are the quantitative links between our most basic theories and the physical reality we wish them to describe . . . The progress of our understanding of the physical world is therefore very much intertwined with the advance of the art of precision measurement . . ." The conference brought together, for the first time in a deliberate and comprehensive way, scientists from major laboratories of the world now working on experimental or theoretical aspects of the drive to fix the fundamental constants with greater accuracy and precision.

Reflecting the organization of conference sessions around particular constants or types of experiment or theory, the proceedings present the text of 84 papers (plus the abstracts only of eight others) under the headings: Frequency and time standards, length standards and the velocity of light, Rydberg constant, electrical standards, proton gyromagnetic ratio, Faraday constant and atomic masses, proton magnetic moment, Josephson effect, x-rays, fine and hyperfine structure in simple atoms (23 papers), Lepton g-factor anomalies, gravitational constants, and panel discussion: Should least squares adjustments . . . be abolished? Among these are 20 invited review papers which, together with contributed papers describing current work by active workers in the field and the discussions following presentation of papers, provide a rather complete picture of the field as it stood in mid-1970.

THE MENZEL SYMPOSIUM

A symposium honoring Donald H. Menzel on his 70th birthday, and dealing with the three areas in which he and his school have pioneered, was held at the Harvard College Observatory April 8-9, 1971. Menzel's work on planetary nebulae represented the first investigations of nonequilibrium thermodynamic conditions in astronomy. The solar work extended these investigations to stellar atmospheres. The applied atomic physics laid the basis for what we now call laboratory astrophysics and, together with work on nonequilibrium thermodynamics, inspired the founding of the Joint Institute for Laboratory Astrophysics. Menzel has served as a distinguished consultant to the Bureau and publication of the Proceedings (*The Menzel Symposium on Solar Physics, Atomic Spectra, and Gaseous Nebulae*, edited by Katherine B. Gebbie, $1.75, SD Catalog Number C13.10:353) represents the Bureau's grateful acknowledgment of his valuable help. The symposium itself was supported in part by the National Science Foundation.

STANDARDS AND CALIBRATION

STANDARD FREQUENCY AND TIME BROADCASTS

High frequency radio stations WWV (Fort Collins, Colo.) and WWVH (Kauai, Hawaii) broadcast time signals on the Coordinated Universal Time (UTC) system as coordinated by the Bureau International de l'Heure (BIH), Paris, France. The NBS time scale, UTC(NBS), and the U.S. Naval Observatory time scale, UTC(USNO), are also coordinated to within ±5 microseconds of each other. Since January 1, 1972, all these time scales have run without frequency offset (formerly −300 parts in 10^{10}), and thus the UTC second has been made equal to the *Systeme International* second.

To maintain this new UTC scale in approximate agreement with UT1 (a time scale related to the rotation of the earth), it will be necessary to add or subtract a "leap-second" every 6 to 18 months. These leap-second adjustments, when necessary, will be made at the end of a month, preferably on December 31 or June 30, and will be announced as early as possible in this space and other publications of NBS. Until such adjustments or other events of special interest occur, there will be no further notices concerning WWV/WWVH operation in the *Technical News Bulletin*. (However, the monthly *Time and Frequency Services Bulletin* issued by the Time and Frequency Broadcast Services Section, National Bureau of Standards, Boulder, Colo. 80302, will continue to be published. Interested parties should contact the Section for subscriptions to that periodical.)

The low frequency radio station WWVB (Fort Collins, Colo.) will continue to broadcast seconds pulses without offset (as before January 1, 1972). However, the designation of its time scale, SAT(Stepped Atomic Time), will be changed to UTC(NBS), and its adjustments will be the same as for the UTC scale discussed above. (Previously, SAT incorporated step adjustments of 200 milliseconds made on the first of the month, as necessary.)

UTC(NBS) as broadcast by WWV, WWVH, and WWVB will be maintained within ±0.7 second of UT1 and with ±1 millisecond of UTC(BIH). For navigators and others who may need to know UT1 to better than 0.7 second, a special code will be broadcast to indicate the difference between UT1 and UTC with a resolution of 0.1 second. If the difference as broadcast is DUT1 = UT1 − UTC, then DUT1 will be indicated in the following manner:

DUT1 will always be an integral number of tenths of seconds, and can be positive or negative, depending on whether UT1 is "fast" or "slow" with respect to UTC. The number of tenths of a second in DUT1 will be indicated by the number of doubled seconds pulses after the minute marker: if the sign of DUT1 is positive, these doubled seconds pulses will occur in the first 7 seconds of each minute, and if DUT1 is negative, the doubled seconds pulses will occur from the 9th to the 15th second. The 8th second marker is not used. Thus, DUT1 = +0.3 second will be indicated by doubling the first, second, and third seconds pulses, and DUT1 = −0.4 second will be indicated by doubling the 9th, 10th, 11th, and 12th second pulses. UTC will be maintained so that DUT1 never exceeds 0.7 second.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Annual subscription: Domestic, $3; foreign, $4. Single copy price 30 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13:56.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.B:74.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.C:74.

NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

Cryogenic Data Center Current Awareness Service (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, $15; foreign, $20.

Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: $15.

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Electromagnetic Metrology Current Awareness Service (Abstracts of Selected Articles on Measurement Techniques and Standards of Electromagnetic Quantities from D-C to Millimeter-Wave Frequencies). Issued monthly. Annual subscription: $100 (Special rates for multi-subscriptions). Send subscription order and remittance to the Electromagnetic Metrology Information Center, Electromagnetics Division, National Bureau of Standards, Boulder, Colo. 80302.

CURRENT ISSUES OF THE JOURNAL OF RESEARCH

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